HALOGETON (CHENOPODIACEAE) IN NORTH AMERICA[1]

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The history, nomenclature, and geography of *Halogeton glomeratus* (Stephan ex Bieberstein) C. A. Meyer in Ledebour in North America have been investigated with attention given to both literature and herbarium specimens. Halogeton received intensive study in the United States between 1942 and 1961 because of its role in the mass mortality of sheep (oxalate poisoning) on western rangelands. Although it is apparently no less common today in the Intermountain Region, sheep mortality has been reduced through educational efforts, and interest in this plant has declined somewhat in recent years. Confusion has existed in the literature, but a herbarium study indicates only one species of halogeton present in the United States now or historically and its identity is confirmed as *Halogeton glomeratus*. Halogeton was introduced into the United States (probably from south-central Russia) earlier than previously reported (i.e. before 1930), live animals (Karakul) being the probable source of introduction. A number of the unnoticed halogeton infestations in the United States were likely initiated by migrating sheep. This species usually does not self-spread over long distances and should only gradually, at most, extend its present range. It will probably not become as widespread, nor represent as great a threat to western sheep flocks, as once was thought.

HISTORICAL PERSPECTIVE

Halogeton, an annual Eurasian chenopodiaceous genus, might well have remained an obscure weed but for the alarm it brought when large numbers of sheep were poisoned in the western United States. Although present in the United States at an earlier date, substantial awareness of halogeton did not come until 1942 when 160 head of sheep were fatally poisoned near Wells, Nevada (Erickson et al., 1952; Flemming et al., 1944). Stomach contents of these dead animals were composed almost entirely of this plant

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material. Subsequent feeding tests performed at the University of Nevada confirmed the strong circumstantial evidence of the poisonous nature of this plant (Flemming et al., 1944). The mass poisoning near Wells led to first attempts (in 1943) to control the weed, a mixture of furnace oil and detergent being employed (Erickson et al., 1952). This and subsequent control measures were largely unsuccessful.

Whereas halogeton was known (at least by a few people) to be present in the United States before 1942, it was not thought to be harmful (Kingsbury, 1964). In fact, it was even considered by some (Erickson et al., 1952) as fair forage for livestock. The casual regard in which halogeton poisoning was initially held in this country was doubtless due to the fact that there were apparently no reports of its toxicity in the Old World (Dayton, 1951), and thus no special reason to suspect it. However, suspicious small losses of livestock in the western United States had actually preceded the Wells incident (Kingsbury, 1964).

After the major poisoning at Wells, numerous minor losses of both sheep and cattle were soon reported in which halogeton was implicated (Erickson et al., 1952). However, a wider recognition of this taxon as a poisonous range plant was to wait until 1945 when 1620 head of sheep perished in a single day near Bridge, in south central Idaho (Morton et al., 1959a). Other severe losses in this Raft River area (Cassia County) included 750 head of sheep belonging to a Mr. John Ward of Almo, Idaho (ZoBell and Silcock, 1950). In fact, the problem became so serious in the mid 1940's that a dozen major sheep ranchers in the Raft River Valley were forced out of business (Stoddart et al., 1951b), finding it necessary in some cases to abandon their ranches. These and other events brought the noxious weed to the attention of the public by 1950, and generated an expansion of research by personnel of the U. S. Department of Agriculture. Popularized reports often took the form of alarming accounts of the spread of this "invader," sometimes with not so subtle innuendoes as to the country of native origin. The following are typical of the frightening titles or inflamatory headlines of the early 50's: "Sheep-Killing Weed," Life Magazine, Jan. 15, 1951; "Poison Rides the Range," Reader's Digest (condensed from the Denver Post), December 1953; "Another Russian Invades U.S.," the National Wool Grower, 1950; and "Soviet Weed Kills Sheep," Oakland Tribune, June 28, 1950. The Life Magazine article contained the statement that more than one-third of the flocks of sheep in the United States were in danger. It was understandably at this time that several agricultural colleges, universities, and range extension agencies in the western states took an active interest in halogeton, initiating various studies into its ecology and possible control. Professional interest was stimulated when the United States Congress appropriated over four-and-a-half million dollars for study in legislation (Halogeton Act, Velie, 1953). Co-operative projects and committees were established in Idaho (Erickson et al., 1952) and Utah (Stoddard et al.,

1951b) to investigate its biology and possible eradication. Warnings of the danger of halogeton appeared in agricultural extension service bulletins of several western states in the early 50's, including Arizona (Armer, 1952) where its occurrence has yet to be documented. Besides the usual admonitions of its effect on sheep, of possible habitats in which it might occur, that it is not controlled selectively by 2,4-D or similar herbicide sprays, and recommendations for trailing sheep so as to avoid it, these bulletins usually described the plant. Particular emphasis was given to means of distinguishing halogeton from the less dangerous Russian thistle (*Salsola kali* L.), another introduced chenopodiaceous plant with which it was sometimes confused. For example, Durrell (1951) stated: "[halogeton] resembles Russian Thistle, which is common throughout the country. However, it has a softer appearance, its leaves are sausage-shaped, succulent and fleshy. The bristle at the tip is softer than the spine on Russian Thistle leaves."

The toxicity and precise effects of halogeton on animals received additional attention during the late 1940's and early 1950's. Flemming et al. (1947), who had earlier (1943) reported halogeton as poisonous (containing oxalic acid), indicated the toxic substances to be "salts of oxalic acid which are elaborated and stored during the growth of the plant to maturity," present as two oxalate salts, water soluble and insoluble. Vawter (1950) subsequently described the mechanism, symptomology, and pathology of halogeton poisoning. Ingestion of only nine ounces will kill a large, mature sheep (weighing 135 to 165 pounds) within six to 10 hours due to "rapidly overwhelming loss of inorganic serum calcium." Vawter (1950, 1951) listed the symptoms as dullness, prostration and coma. Kidney sections examined under polarized light show large crystal aggregates of calcium oxalate in the tubules. Anderson and Huffman (1957) indicated these changes resulted in acute renal failure. According to Vawter (1950) there "seems to be no practical way of saving sheep after eating a lethal dose of the plant." The toxic form of oxalate was determined by Dye (1956) to be the soluble form, insoluble calcium oxalate being relatively harmless. Binns and James (1961) discussed the mechanism of sodium oxalate in the blood in precipitating calcium (with resultant alkalosis) and stated that the feeding of alfalfa pellets, supplemented with dicalcium phosphate, was helpful in preventing (not curing) poisoning in sheep.

More detailed study of the physiology of halogeton, particularly oxalate content and metabolism, was the concluding phase of an intensive two-decade study. Morton et al. (1959b) determined the oxalate content of plants to range from 18 to 21 percent of dry weight (about the usual range reported in the literature), declining somewhat during the growing season. Most of the oxalate was contained in the leaves, with relatively small amounts in the stems, and high oxalate concentration was associated with a high sodium content. Williams (1960) observed that soluble oxalate content of the plant, as well as growth and succulence, increased when sodium (as

NaCl) was added to nutrient solutions. In contrast to Morton et al., Williams found that the concentration of oxalate in the leaves continued to rise during the summer, attaining a peak in September. According to Williams, the leaves of vigorous plants often contain in excess of 30 percent soluble oxalate on a dry weight basis, with an additional three or four percent of the dry weight of the plant accounted for by insoluble oxalate. A dry-weight soluble oxalate content of 34.5 percent was reported by Cook and Gates (1960), a high percentage compared to most other oxalate-containing plants. Kingsbury (1965) indicated a 10 percent soluble oxalate content to be high for beet tops (considered potentially dangerous forage), well below the usual estimates for halogeton.

Both popular and scientific literature on halogeton decreased after 1961, although Kingsbury (1964) devoted attention to it in his comprehensive work on poisonous plants of the United States and Canada. Sheep losses from oxalate poisoning also declined, apparently from an awareness among sheep ranchers. Nonetheless, occasional reports of severe loss, particularly in Utah, continued to surface in various newspapers. As recently as 1971 (Associated Press, Salt Lake City, January 23), 1,180 head from a flock of 2,400 died near Garrison, Utah, close to the Nevada border. This report observed that "there's halogeton all over that area." Thus, a "slow down" in the literature probably did not reflect a decrease in populations, but rather indicated better education concerning the plant, a lessening of the earlier somewhat faddish interest in the weed, and the realization that halogeton would not actually kill one out of three sheep in the United States (as suggested by Life Magazine).

Questions left unanswered or inadequately answered include: When did halogeton enter the North American flora and by what means? What has been the pattern and the mechanism of its spread? Is it more common now than it was say 30 years ago? What is its probable future in the flora? Is more than one species of *Halogeton* present in the United States? And, perhaps surprisingly, what is actually the correct scientific name(s)? By taking a close look at the history of the literature on halogeton, and by examination of actual specimen records, this paper attempts to deal with these questions.

NOMENCLATURE

Since its appearance in the flora, three different names for halogeton in North America have found their way into the literature: *Halogeton sativus, H. souda,* and *H. glomeratus.* These three names are to be found among specimens in North American herbaria (although *H. glomeratus* is the common determination).

In 1936, the 77th Intermountain Forest and Range Experiment Station collection was forwarded to the Washington Office of the United States Forest Service (Dayton, 1951). These plants included two specimens (S-43 and S-44, collected in 1934 by Ben Stahmann, a Forest Service officer, one

mile northeast of Wells, Elko County, Nevada) which were the first records of halogeton for the U.S. These two specimens were not immediately identified. However, similar material (Field Museum, F 780344 and F 815074) collected by Mr. Stahmann from Wells in 1935 was subsequently determined by Dr. Paul Aellen, an authority on the Chenopodiaceae, as "*Halogeton sativus*" (based on *Salsola sativa* L., 1762), native to Spain and Algeria.

Standley (1937) first published on halogeton in North America, accepting Aellen's determination of Stahmann's 1935 material as *Halogeton sativus* (L.) C. A. Meyer. Standley, seemingly unaware of Stahmann's 1934 collection, commented that the genus was first collected in "1935" at Wells, and speculated that "it will be interesting to learn whether this new addition to the United States flora thrives as well as *Bassia hyssopifolia* (Pall.) Kuntze, a related plant of somewhat similar appearance, which, if I remember correctly, also was found in the United States first in Nevada." Standley further stated that "it [halogeton] is reported to be spreading rapidly." Confusion persisted in the literature as to whether the initial collection of halogeton was made in 1934 or 1935 (e.g. ZoBell and Silcock, 1950); however, herbarium records clearly show that 1934 is correct.

The question of the initial year of collection has not been the only confusion enshrouding halogeton in North America. Morton (1941) correctly observed that the publishing author of the combination *Halogeton sativus* was actually Moquin-Tandon (1840), rather than C. A. Meyer (as suggested by Standley and presumably also by Aellen). Although Meyer (1829) mentioned *Salsola sativa*, he never employed the combination *Halogeton sativus* (as did Moquin-Tandon). Therefore, the correct citation is *Halogeton sativus* (L.) Moquin-Tandon, not (L.) C. A. Meyer. However, Morton (1941) went on to discuss the existence of an earlier name for this species, viz. *Halogeton souda* (Loefling) Macbride (based on *Salsola souda* Loefling, 1758). Our examination of photographs of the type specimens of both *Salsola sativa* and *S. souda* in the Linnaean herbarium (LINN) confirms that they are probably the same species. Thus, if the adventive American taxon were considered to be the Spanish-Algerian species, *Halogeton souda* would be the correct name (on the basis of priority), with *H. sativus* relegated to synonymy. Fosberg (1940) used the name *H. souda* for halogeton in Nevada.

The question of *Halogeton sativus* vs. *H. souda* is relatively moot to our considerations, however, because Morton (1941) further indicated that North American specimens are not *Halogeton souda* (*H. sativus*) at all but belong instead to a Russian species, *Halogeton glomeratus*. It is apparent that Morton examined Old World specimens of both *H. souda* and *H. glomeratus*, although probably not the type specimen of either. Dayton (1951) subsequently offered a brief review of these taxonomic and nomenclatural problems, concurring with Morton. However, Dayton stated that the type of *H. glomeratus* was behind the "Iron Curtain," presumably in Moscow or Leningrad, and not available for examination. Thus, ultimate

certainty of the identity of North American specimens must have eluded both Morton and Dayton.

Through the auspices of Dr. V. I. Grubov, we obtained a loan of specimens from the Leningrad herbarium (LE), along with photographs (negatives) of the type specimen of *H. glomeratus*. Prints made from these negatives matched well with the specimens collected in the United States. Thus, North American specimens can now be classified with reasonable assurance as *H. glomeratus*, not *H. souda* (*H. sativus*).

Dayton (1951) and others indicated that the combination *Halogeton glomeratus* is traced to C. A. Meyer (1829) when he described the genus in Ledebour's *Flora Altaica*. Dayton, however, noted that C. F. Stephan (author of a Flora of Moscow) was actually the first to use the epithet (in connection with herbarium material) but that Stephan himself did not publish it. Stephan's specimen, however, is the type of *Halogeton glomeratus*, and is the specimen in the Leningrad herbarium. This specimen (lacking a date) is labeled "*Salsola glomerata*" in Stephan's handwriting. The name written by Stephan is a herbarium or "manuscript" name. However, Stephan's epithet "*glomerata*" was later validly published by Marshall von Bieberstein (a colleague of the well-known Russian botanist, Pallas) as *Anabasis glomeratus* (1806). Meyer (1829) subsequently transferred Bieberstein's *glomeratus* to *Halogeton*. The most complete and accurate author citation of the name (which we have understandably not seen published) would be *Halogeton glomeratus* (Stephan ex Bieberstein) C. A. Meyer in Ledebour.

Tutin (1964) considered *Halogeton glomeratus* and *H. sativus* (= *H. souda*) to be closely related species. In addition to the geographical separation, the Spanish species is to be distinguished by longer leaves, a more robust habit, longer perianth, and a greater number of stamens per flower. Our examination of specimens and phototypes lends support to those who separate these two species. However, if a future monographer were to combine *H. glomeratus* and *H. souda*, the name would then become *H. souda* on the basis of priority.

Halogeton, as is the case with many other chenopodiaceous genera, is in need of revision on a worldwide basis. This is evident from the variation in estimates as to the number of species of which the genus is composed: Ulbrich (1934) indicated that there are three species; Iljin (1936) called for four; and, somewhat inexplicably, Dayton (1951) suggested that there are 12. Regarless of whom one believes, there is agreement that more than one species exists. However, we consider that only one species (*H. glomeratus*) has been and is in the flora of the United States. We find no evidence to support Dayton's (1951) speculation that "it is perhaps only a question of time when one or more of these other species will emigrate to this country."

INTRODUCTION, SPREAD, AND DISTRIBUTION

Neither the manner nor the date of introduction of halogeton into the United States has been definitely established (Tisdale and Zappetini, 1953). Several references (Bellue, 1949; Standley, 1937; ZoBell and Silcock, 1950) indicated halogeton first entered the North American flora in 1935, although it was already common in the Wells area by 1934 (Dayton, 1951). It is apparent in the case of several "first records" for particular regions that infestations were extensive at the time of discovery (Bellue, 1949; Velie, 1953). Even the nature of various of the livestock losses reported, i.e. severe and sporadic, is an indication that it became abundant in certain areas prior to recognition. Stoddard et al. (1951b) set the time of entry back somewhat in suggesting the probable date of introduction from southern Russia "in about 1930." Binns and James (1961) likewise favored 1930 as a likely date of introduction.

Regardless of the exact time of introduction, it appears that halogeton became more common in western North America in the early 1930's. During this period an extremely dry climatic circumstance prevailed throughout most of the West. It is probable that the drought tolerant halogeton extended its populations (at least locally) while many native species suffered decline (Tisdale and Zappetini, 1953). This species does not compete well with healthy native perennial forbs (Fenley, 1952), yet it enters in force when soils are denuded (Erickson et al., 1952). As many as 50,000 winged seeds per plant (Morton et al., 1959a) are dispersed locally by the wind (Kingsbury, 1964). This and a wide ecological tolerance range permits halogeton to survive in habitats unfavorable to competitors (Erickson et al., 1952) and to "take over" local disturbed or barren areas quickly. The "Dust Bowl" of the western United States in the 1930's assuredly contributed to its spread.

Although undocumented, halogeton must have been present in North America before 1930 (Erickson et al., 1952). Erickson and his coworkers suggested three possible sources of introduction: 1) impurity in crop seed, 2) imported wool, or 3) importation with breeding stocks of sheep. Durrell (1951) and an anonymous writer in Life Magazine (1951) supported the introduction into this country as a contaminant in imported seed. Erickson et al. (1952) favored wool pelts or live animals as the vector, pointing out that new infestations coincide with sheep movements. Bellue (1949) simply commented that "Halogeton seed seems to have an affinity for and readily sticks to the wool of sheep," and that in Nevada, Utah, Idaho and Wyoming, the weed has "followed sheep trails and bedding grounds." Karakul sheep, among other possibilities, has been mentioned as a potential source of introduction and the most likely vector from the Soviet Union. In contrast to other breeds (including Angora), the natural range of the Karakul corresponds closely to that of halogeton. Karakul are native to desert-like areas of the Bokhara Province of southern Russia, and sheep with Karakul blood extend as far westward as the Caspian and Black Seas (Vaughan, 1931).

Halogeton glomoratus is well known from this general area (Iljin, 1936). Erickson et al. (1952) mentioned that both Karakul and Angora breeding stocks were imported into the United States between 1908 and 1925. Wentworth (1948) also alluded to the importation of Karakul early in the twentieth century. Vaughan (1931) identified "three lots" of Karakul that were imported (by Dr. C. C. Young), in 1908, 1912, and 1914 respectively. If Karakul were the vector, then 1908-1914 would be more likely the time of introduction than 1930 to 1934.

Circumstantial evidence for the ovine origin of halogeton infestation is found in the implicating comparison (Figure 1) between sizeable halogeton populations and major sheep trails of the early part of the century (these trails were in heavy use until about 1915). Several primary routes were used in sheep drives out of California (Wentworth, 1948), including southern (leaving Bakersfield), middle (leaving Fresno), and northern (leaving Red Bluff) passages. The southern and middle routes passed along the eastern flank of the Sierras, then across Nevada, proceeding through Wells (a major trail junction), and up into the Raft River Valley of southern Idaho. Tisdale and Zappetini (1953) pointed out that the Raft River Valley area was one of the principal winter ranges for sheep in the early 1900's. The northern route passed directly through the well-documented area of infestation in Lassen County, California, on the way to Wells and southern Idaho. Thus, the correlation between major sheep trails and a number of significant halogeton infestations is, in our opinion, not coincidental (Figure 1). Localities plotted are based on specimens examined from the following herbaria (Holmgren and Keuken, 1974): A, ARIZ, DAO, F, GH, ID, MU, NY, OSC, PENN, PH, RENO, RM, SMU, UC, US, USFS, UT, and WTU. Additional information on specimens was provided by: CAN, COLO, TEX, and UNM.

We consider, by virtue of the native home of the Karakul, its long fur (Persian lamb's wool) in which seeds might easily become entangled, the time of introduction of Karakul into the United States, and the apparent relationship between old sheep trails and the distribution of the plant, that halogeton was both introduced and subsequently dispersed by live sheep. Introductions by means of fur pelts or grain shipments are conceivable, but not as probable. Karakul skins were mailed in bundles of 500 each from Asia directly to New York City where they were processed (Vaughan, 1931), and therefore had no connection with halogeton growing in the western states. Grain shipments contaminated with halogeton seed could have accounted for a few populations of halogeton. Seed contamination has played a major role in the introduction of certain other chenopodiaceous weeds (Blackwell, 1978; Collins and Blackwell, 1979). But if the majority of infestations had actually been caused by contaminated grain, there should be no correlation between its occurrence and well-known sheep trails. Also, railroads for shipping grain were not established early in the 1900's through

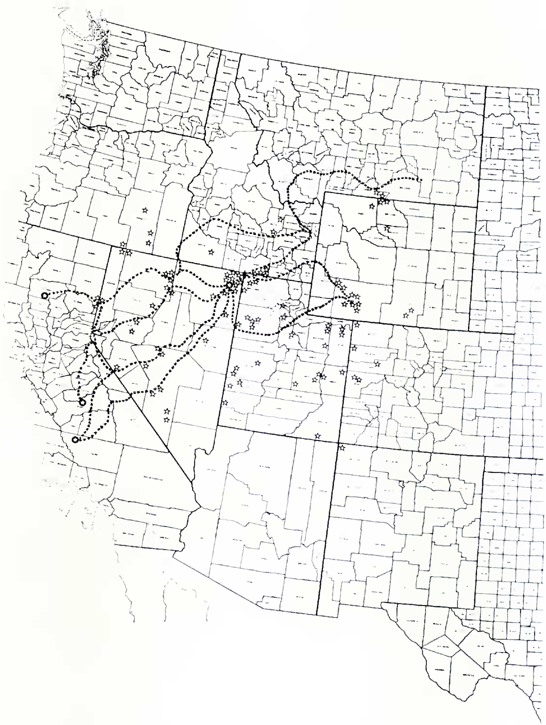

Figure 1. Distribution of *Halogeton glomeratus* in North America. Stars with thickened circular borders in California represent major sheep trail departure points (North to South, respectively, Red Bluff, Fresno, and Bakersfield). Star with thickened circular border in northeastern Nevada (Elko Co.) represents major sheep trail junction at Wells. Other stars (lacking thickened circular borders) represent locations of Halogeton populations based on herbarium specimen records. Sheep trails (double broken lines) are modified from E. N. Wentworth, 1948, *America's Sheep Trails.*

some of the areas of heaviest infestation. Thus, live animals, in particular the Karakul, would seem to have been the vector, and we believe halogeton to have been present and growing in the United States by 1915. It is somewhat ironic that the type of animal (sheep) which has been most adversely affected by its toxicity also appears to have been the source of introduction and dispersal.

The assumption (e.g. Stoddard et al., 1951b; ZoBell and Silcock, 1950) that halogeton was first introduced into Nevada, from there spreading to the other states (Utah, Idaho, Wyoming, etc.), may be invalid. Even though it spreads locally in great numbers, there is no evidence that it is dispersed across large distances without the aid of an external vector (such as sheep). Kingsbury (1964) indicated that wind is primarily effective only in local dispersal. Thus, a majority of present extensive areas of infestation probably correspond to the original sites of introduction by migrating sheep. While Wells, Nevada, was one of those early sites, it is *not* possible to be sure that it was *the* earliest. It is reasonable to say only that it was first collected there. It is conceivable, for example, that one or more of the Raft River Valley localities in Idaho might predate the Wells, Nevada, occurrence. There is no proof one way or the other. Since halogeton was present for a number of years, probably in a number of locations, prior to its discovery, it is not likely that the first site of occurrence in this country will ever be conclusively identified. But even if Wells were accepted as the initial locality (as it is in much of the literature), an autogenic spread of halogeton from there to other widely separated localities is less than plausible.

Bellue (1949) inferred that halogeton migrated from northwestern Nevada (located across the state from Wells) over the border into Lassen County, California. Yet, this rather isolated occurrence in northeastern California may have had nothing to do with its presence in Nevada. The California infestation could just as well have been initiated in situ in the early 1900's by a sheep drive. Bellue stated that "a survey made subsequent to our first California record in Lassen County in 1946, indicated that Halogeton had become scattered over several thousand acres." This extensive infestation did not develop overnight and it seems as feasible to us to speculate that halogeton had been there for some time (the introduction having taken place at or near the site) as to postulate a recent invasion from adjacent Nevada.

We believe that, whereas it is possible to determine a pathway of infestation (and a probable cause), it is not possible to establish meaningful chronology. Halogeton was, we think, independently and separately introduced by sheep into scattered localities, sooner or later becoming locally common in some of them; and since these introductions probably took place well before discovery of the plant, the order in which they transpired cannot be determined. If it were possible to establish the chronology of infestation, however, it is unlikely that it would follow an orderly geographic

sequence. Based on herbarium specimen records, and without any necessary implication of the sequence of spread, we can state that the first collections known in the following states were in the following order: Nevada, 1934; Utah, 1943; Wyoming, 1943; Idaho, 1946; Montana, 1951; California, 1951; Colorado, 1951; Oregon, 1954; and New Mexico, 1973. Halogeton was observed five years prior to collection in California (Bellue, 1949) and at least one year before collection in Idaho (Morton et al., 1959a). Thus, specimen records offer only a rough gauge of the time of awareness of its presence in the various states, and little or nothing about the actual time of its appearance in the state's flora.

Opinion has varied as to the prognosis for halogeton in North America. Holmgren (1950) stated that "it's migration into new areas is continuing at an alarming rate," and such a sentiment is echoed in popular articles in Life Magazine (anonymous, 1951) and Reader's Digest (Velie, 1953). More conservatively, Erickson (1952) stated that "the future distribution of halogeton cannot be forecast with accuracy at this time." Erickson did mention the possibility that it could eventually spread over the entire Intermountain Shrub Zone (Cold Desert region) and even into the western margins of the grasslands lying to the east. Perhaps it was simply too early, and with too little information at hand, to forecast accurately the future of halogeton in the United States, except to postulate that it would certainly persist (Stoddart et al., 1951a) and probably would not become any less common with time.

It appears that the present major areas of halogeton infestation are essentially those depicted in publications of the 1950's. Simple maps presented by Erickson et al. (1952) and the U. S. Department of Agriculture (anonymous, 1958), outline these areas rather well. To the USDA map, new localities can be added primarily in southern Oregon and northwestern New Mexico. According to herbarium records, no new "halogeton states," except for New Mexico, have been added to the list since 1954. Thus, it would seem that whereas halogeton can and does spread locally at a rapid rate, it does not readily establish new widely disjunct areas of infestation by its own devices. Bellue (1949), for example, noted that "the range of Halogeton is still confined to the original general location in the southeastern corner of Lassen County." And in the summer of 1977, two of us (Blackwell and Hopkins) carried out an extensive search throughout adjacent Modoc County, California, without turning up a single specimen. Suitable habitats were apparently abundant in Modoc County, yet halogeton had not spread there in more than 30 years of opportunity from either Lassen County or adjacent Nevada. Morton et al. (1959a) indicated that the total area of halogeton infestation was 10.5 million acres (though it is not clear how this figure was derived). It does not seem that the area of infestation today is much larger than this, although an accurate estimate is lacking. When compared with the USDA map of 1958, major areas of infestation do not

appear to have increased strikingly. This is not to imply that there have not been numerous instances of local increase, or numerous rather closely spaced small new infestations in various parts of the Intermountain Region. Undoubtedly, the fact that major sheep drives have drastically declined as a means of transporting sheep great distances is related to the present minor spreading of the plant. New areas of halogeton infestation now perhaps most commonly originate in disturbed habitats along roadways (personal observation, Blackwell, southern Oregon, 1977). Infestations in eastern Utah and western Colorado, New Mexico, and Oregon apparently developed in this manner. Thus, spread (not necessarily rapid) along roadsides allows movement into poorly managed rangeland.

Control of halogeton remains a concern. Of the various alleged methods, biological control has come to be among the more common suggestions. In particular, the use of crested wheatgrass (*Agropyron cristatum* Gaertn.) as a competitor was recommended (Fenley, 1952; Stoddart et al., 1951a). However, this, as various chemical control measures, produced dubious results (Morton et al., 1959a). Halogeton and crested wheatgrass were observed growing successfully together in Lake County, Oregon (Blackwell, personal observation, summer 1977). Perhaps Morton and his collaborators (1959a) summarized it best in stating that "the successful control of halogeton does not depend upon any single control method . . . Ultimate control of halogeton depends upon the restoration of vigor and productivity to good range forage plants."

REFERENCES

ANDERSON, W. A. and W. T. HUFFMAN. 1957. Halogeton poisoning in a ewe. J. Am. Vet. Med. Assoc. 130: 330–331.

ANONYMOUS. 1951. Sheep-killing weed. Life Magazine, Jan. 15: 55–56.

ANONYMOUS. 1958. Reducing livestock losses from halogeton poisoning in the western states. U.S. Dept. Agri. Bull. PA-321. 3 pp.

ARMER, W. 1952. Halogeton—a stock-poisoning weed. Ariz. Agri. Exp. St. Bull., Ext. Circ. 197. 3 pp.

BELLUE, M. K. 1949. Halogeton invades California. Calif. Dep. Agri. Bull. 38(1): 32–36.

BIEBERSTEIN, F. A. M. VON. 1806. *Anabasis*. Societe Imperiale des Naturalistes de Moscov, Memoires, vol. 1 (ed. 2): 108–112.

BINNS, W. and L. F. JAMES. 1961. Halogeton and other oxalic acid poisonings. Proc. Am. Col. Vet. Toxicol. 1960: 5–8.

BLACKWELL, W. H. 1978. The history of Russian pigweed, *Axyris amaranthoides* (Chenopodiaceae, Atripliceae), in North America. Weed Sci. 26: 82–84.

COLLINS, S. L. and W. H. BLACKWELL. 1979. *Bassia* (Chenopodiaceae) in North America. Sida. 8: 57–64.

COOK, C. W. and D. H. GATES. 1960. Effects of site and season on oxalate content of halogeton. J. Range Manage. 13: 97–101.

DAYTON, W.A. 1951. Historical sketch of barilla (*Halogeton glomeratus*). J. Range Manage. 4(6): 375–381.

DURRELL, L. W. 1951. Halogeton: a new stock-poisoning weed. Colo. Agri. Exp. St. Circ. 170-A. 5 pp.

DYE, W. B. 1956. Chemical studies on *Halogeton glomeratus*. Weeds 4: 55–60.

ERICKSON, L. C., H. L. MORTON, E. W. TISDALE, and G. ZAPPETINI. 1952. The present status of the halogeton problem. Weeds 1(4): 321–328.

FENLEY, J. M. 1952. How to live with halogeton while limiting its spread and reducing loss. Nev. Agri. Ext. Serv. Bull. 106. 20 pp.

FLEMMING, C. E., M. R. MILLER, L. R. VAWTER, and W. NEILSON. 1943–1949. Poisoning range plants. Nev. Agr. Exp. St. Ann. Rpts.

FOSBERG, F. R. 1940. Chenopodiaceae of Nevada (in part). Contrib. Toward a Flora of Nevada, No. 8: 1–18. Mimeographed.

HOLMGREN, A. 1950. Halogeton invading eastern Utah winter ranges. Utah Agri. Exp., St., Farm Home Sci., 11(4): 87.

HOLMGREN, P.K. and W. KEUKEN. 1974. Index herbariorum (6th ed.). Regnum Veg., Vol. 92. Oosthoek, Scheltema and Holkema, Emmalaan 27. Utrecht, Netherlands, 397 pp.

ILJIN, M. 1936. Cheonpodiaceae. In V. L. Komarov and B. K. Shishkin. Flora of the USSR, 6: 4–272. (English Translation, 1970, by N. Landau.)

KINGSBURY, J. M. 1964. Poisonous plants of the United States and Canada. Prentice Hall, Inc., Englewood Cliffs, New Jersey. 626 pp.

KINGSBURY, J. M. 1965. Deadly harvest. Holt, Rinehart and Winston, New York. 128 pp.

MEYER, C. A. 1829. *Halogeton* In C. F. Ledebour. Flora Altaica, 1: 378–380.

MOQUIN-TANDON, C. 1840. Chenopodearum monographica enumeratio. 182 pp.

MORTON, C. V. 1941. A note on halogeton. Leafl. West. Bot. 3(2): 45–46.

MORTON, H. L., R. H. HAAS, and L. C. ERICKSON. 1959a. Halogeton and its control. Idaho Agri. Exp. St. Res. Bull. 307. 24 pp.

MORTON, H. L., R. H. HAAS, and L. C. ERICKSON. 1959b. Oxalate and mineral contents of *Halogeton glomeratus*. Weeds 7(3): 255–264.

STANDLEY, P. C. 1937. Studies of American plants—VIII. Field Mus. Nat. Hist. Publ., Bot. Ser., 17(3): 225–284. (Publ. 395).

STODDART, L. A., G. T. BAIRD, G. STEWART, R. S. MARKHAM, and H. CLEGG. 1951a. The halogeton problem in Utah. Utah Agri. Ext. Serv., Bull. 250. 12 pp.

STODDART, L. A., H. CLEGG, B. S. MARKHAM, and G. STEWART, 1951b. The halogeton problem on Utah's ranges. J. Range Manage. 4(4): 223–227.

TISDALE, E. W. and G. ZAPPETINI. 1953. Halogeton studies on Idaho ranges. J. Range Manage. 6(4): 225–236.

TUTIN, T. G. 1964. Chenopodiaceae. In Tutin et al. Flora Europaea, 1: 90–108.

ULBRICH, E. 1934. Chenopodiaceae. In Engler and Prantl. Die Natürlichen Pflanzenfamilien (ed. 2), 16c: 379-584.

VAUGHAN, H. W. 1931. Breeds of livestock in America. R. G. Adams and Co., Columbus, Ohio. 780 pp.

VAWTER, L. R. 1950. *Halogeton glomeratus*—a range plant poisonus to sheep and cattle. Calif. Vet. 3(6): 12.

VAWTER, L. R. 1951. Halogeton poisoning in sheep. Natl. Wool Grower 41(2): 24–25.

VELIE, L. 1953. Poison rides the range. The Reader's Digest. December: 79–82. (Condensed from the Denver Post, Nov. 8, 1953).

WENTWORTH, E. N. 1948. America's sheep trails. Iowa State Univ. Press, Ames. 667 pp.

WILLIAMS, M. C. 1960. Effect of sodium and potassium salts on growth and oxalate content of halogeton. Plant Physiol. 35: 500–505.

ZOBELL, R. S. and B. W. SILCOCK. 1950. Another Russian invades U.S. Natl. Wool Grower 40(4): 22.